THE TREATMENT OF CEREBRAL PALSIES AND ATHETOSIS BY NERVE ANASTOMOSIS AND TRANSPLANTATION.[1]

By William G. Spiller, M.D.,
OF PHILADELPHIA,
PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, AND SURGEON TO THE UNIVERSITY HOSPITAL.

AND

Charles H. Frazier, M.D.,
PROFESSOR OF CLINICAL SURGERY AND SURGEON TO THE UNIVERSITY HOSPITAL IN THE UNIVERSITY OF PENNSYLVANIA.

REMARKS BY DR. SPILLER.

The views presented in this paper are put forward with much hesitation, because the means by which voluntary power is restored in hemiplegia are unknown, and the conditions have resisted most attempts at improvement. The views here expressed are original with the authors, and if experience should prove that they are fallacious, they may nevertheless afford some suggestions for further investigations. We should have preferred to wait until these investigations had been carried to a successful conclusion before making any reference to them, but it may be better to invite discussion on the subject.

Is it possible to benefit in any way by surgical means the patient who is afflicted with an incomplete hemiplegia? This is a question I have repeatedly proposed to myself. Where the hemiplegia is complete or nearly complete we can not hope to accomplish anything by any surgical procedure. There are, however, many cases in which there is a partial return of power in the paralyzed limbs, and experience shows that usually the restoration of motion is greater in the flexors in the upper limb and greater in the extensors in the lower limb, except those of the toes. I have—to give one example—under my observation at present a man, aged twenty-seven years, who has had left hemiparesis so long as he can remember. He has excellent power in the flexors of the hand, but can extend the hand and fingers only to the plane of the forearm, and he has no contractures. In the lower limb he can not extend the toes or dorsally flex the foot, although he can extend the foot with much power, and in walking raises the left knee a little more than the right, because the left lower limb is too long. An operation on the upper limb would not be permissible, because the flexors of the fingers are more useful than the extensors, and he can extend the fingers to a level with the back of the hand. In other cases, however, the difference in the degree of power of the flexors and extensors of the fingers and hand is greater, and the restoration of power may occur almost alone in the flexors. The latter may be contractured so that the hand is flexed on the forearm and the fingers flexed into the palm. The restoration of the power of the flexors of the fingers and hand may be of little or no value, unless there is at least a partial return of power in the antagonistic muscles, although this return need not be so great in the extensors as in the flexors. I have thought that in a case where the flexors alone regain power we might anastomose the central ends of some of the least important of the flexor nerves with the peripheral ends of extensor nerves, and in this way restore more nearly the normal relation between the flexor and extensor muscles. In the case I have referred to above, in which the flexors of the toes were much stronger than the extensors, an anastomosis of the central ends of one or more flexor branches with the distal ends of extensor nerves might be of decided advantage. Even though the hemiparesis has existed many years, regeneration of the united nerve ends would occur, because these nerves still have power and their connection with their spinal cells of origin has never been impaired. The muscles of course must not be entirely wasted.

---

[1] Read by invitation before the New York Neurological Society, March 7, 1905.

From the Laboratories of Neuropathology and Surgical Pathology in the University of Pennsylvania.

The question now arises, would impulses pass from the brain over the central motor tracts to the anastomosed fibers in such a way that useful return of function might be expected? I think the probability is that such a restoration in part at least would occur. It is true that movements and not muscles are represented in the brain cortex, but it has been demonstrated that when the lesion is in the peripheral nerves and anastomosis of nerves has been performed, a new form of associated movements may be learned by the brain.

We need not enter into a discussion of the manner in which return of function occurs after hemiplegia. Whether there is a close association in the brain of the fibers for the agonistic and antagonistic muscles, to use the terms employed by certain German writers, as Mann believes, need not concern us now. The partial return of power after a hemiplegia, according to the view of Rothmann, may be the result of independent function newly acquired by subcortical centers, especially by the optic thalamus, and is such as exists normally in lower animals, or is developed in the monkey a few days after destruction of the cortical centers for the limbs.

It is certain that for perfect voluntary motion we must have return of power in both agonistic and antagonistic muscles. We can not flex a finger properly unless the extensor of that finger is in the requisite degree of tonicity. If we flex the fingers of one hand firmly into the palm and place the other hand over the extensors of the wrist, we find that the extensors of the carpus become tense. It is in large measure because of this loss of extensor power, and thereby of fixation of the hand, that flexion of the fingers is weakened when we have wrist drop from a lesion of the posterior interosseous nerve.

In order to study the conditions of paralysis existing in hemiplegia I have examined twenty-six cases in which the paralysis dated from early childhood. Dr. Martin W. Barr kindly had collected for me all the cases of infantile hemiplegia at present in the Pennsylvania Training School for Feeble-Minded Children. I wish to thank Dr. Jennings and Dr. Weisenburg for their assistance in the study of these cases.

The return of power is, I think, greater on the average in cases in which the hemiplegia develops in childhood than in those in which it develops in adult life. These twenty-six cases were not selected from a large number of hemiplegics, and yet in eleven of these the voluntary power in the flexors of the hand and fingers was much greater than in the extensors; and in four of these the voluntary power of the flexors of the toes and extensors of the foot was much greater than in the extensors of the toes and flexors of the foot. The cases in which the hand had regained partial power were more numerous than those in which the foot had regained partial power. In eleven cases out of twenty-six, therefore, the flexors of the hand were so much stronger than the extensors that a nerve anastomosis might properly be attempted, but only four cases offered much hope for improvement from an operation on the foot. All cases in which the restoration of power in the extensors of the hand and fingers was fair, even though less than in the flexors, were rejected as being undesirable for operation. As one of the most suitable cases the following may be briefly described:

L. A., female, aged thirty-one years, high grade imbecile, has voluntary movements at all parts of the right upper limb, but the movements are impaired. The fingers of the right hand are slightly flexed into the palm. She has considerable power in the flexors of the right hand, but no power in the extensors. In making a bed she is able to hold the bed clothing with her right hand, but the use of the hand is much diminished by the permanent flexion. The paralysis in the muscles of the right foot is almost complete.

There is probably therefore a field for surgical intervention in certain cases of cerebral hemiplegia, but the cases must be carefuly selected, and each thoroughly studied. Whether any benefit by nerve anastomosis will result to the hemiplegic individual or not, experience alone will decide. The subject, however, is one deserving attention. Dr. Frazier has in one case operated upon the hand of a partially hemiplegic woman, but the return of power following the hemiplegia has not been sufficient until the present time to make the intervention entirely satisfactory. He will describe his method of anastomosing the nerves. He has also made investigation upon dogs concerning the results of anastomosing flexor nerves with extensor nerves.

Tendon transplantation for the increase of function in paralysis of all varieties has proved of benefit provided the paralysis is not progressive,—a subject upon which Oppenheim has written within the last few weeks—but where nerve anastomosis or transplantation is successful we have a means of restoring the function of muscles previously paralyzed, and therefore this method is better than tendon transplantation which makes no demand on paralyzed muscles.

I am well aware that improvement may occur in hemiplegia years after the paralysis has first developed.

Athetosis is one of the most distressing forms of involuntary movement, and the failure to control it in any degree is a reproach to medicine. I have for several years been trying to devise some method of treatment for this condition. Much study has been given to the causation of these movements, but our knowledge regarding the condition is very insignificant. There must in cases in which athetosis exists be an irritation of the motor system somewhere, and the investigations of recent years (Bonhoeffer, Mann) seem to point to implication of the superior cerebellar peduncle. We can not hope to remove the irritation in the brain. We can not hope to cut the central motor fibers. Such a procedure would be unjustifiable. Can we accomplish anything by operation upon the peripheral nerves?

Where athetosis exists the muscles are in a state of greatly increased tonicity and often are abnormally well developed and abnormally strong. Theoretically the proper procedure might be to cut posterior roots of the affected limbs, the number to be cut depending on the condition in each case; but this is always a serious operation, and the results have at times been unexpectedly grave.

It is possible that if we were to divide one or more of the motor nerves of the affected limb and immediately suture the divided portions we might lessen the involuntary activity and weaken the muscles only slightly; or if experience taught us to make the paresis greater by making the conditions for full restoration of power less favorable, we might be justified in leaving some of the nerves divided, or even in making reunion of certain ot the nerves improbable. It is possible that in this way we might diminish the nervous impulses sent out continually and involuntarily from the brain, or at least check their manifestation. In athetosis the flexors of the hand and fingers are often unusually strong, and where this is the case the union of the peripheral end of a flexor nerve with the central end of an extensor nerve and *vice versa*, might restore the proper relations of voluntary power and lessen or abolish the involuntary movements. We have at present a case of marked flexor spasm with athetosis on which Dr. Frazier will operate.[2]

Nerve transplantation if the lesion is in the spinal cord is a hopeful field for surgical intervention when the conditions are favorable. I[3] have already discussed this subject in association with Dr. Frazier, in a paper read before the Section on Nervous and Mental Diseases of the American Medical Association in June, 1904, and may say here that paralysis confined to one or a few muscles is not an uncommon occurrence in anterior poliomyelitis, and that the cases in which nerve anastomosis may be done are therefore fairly numerous.

REMARKS BY DR. FRAZIER.

The adaptation of the operations known as nerve anastomoses or implantations, to the treatment of cerebral palsies, as proposed by Spiller, opens up a field in neurological surgery which seems to me to be full of promise. There are innumerable details in the method of executing the operation, which can be determined only by thorough and repeated experimental investigations and clinical observations. A series of experiments is now being conducted by us, but few have as yet reached the stage which warrants their publication. Our first clinical experience dealt with a woman 65 years of age, who five years ago had an apoplectic attack. When the operation was performed, July 28, 1904, she was hemiplegic; there was marked atrophy of the muscles of the hand, forearm and arm, but the paralysis was so much more marked in the extensor than in the flexor group of muscles that she could partially, and this only with great difficulty, extend the proximal phalanges. Her hand was a greater part of the time held in partial flexion. Under ether anesthesia an incision was made along the inner border of the coraco-brachialis, exposing the brachial vessels and the main nerve trunks. The median and musculo-spiral nerves were isolated sufficiently for our purpose and a flap, composed of one-half of the median nerve, with its base centralwards, was implanted into the musculo-spiral. Union was effected by making a longitudinal incision in the sheath of the musculo-spiral into which the free end of the flap from the median nerve was introduced and sutured in such a way that the nerve fibers of the median were imbeded into those of the musculo-spiral. The results of the operation up to the present time have not been very positive although it is still possible that as time goes on greater improvement will be noted. There is probably distinct improvement in the extension of one of the fingers. It is too early yet to predict the result.

---

[2] Since this paper was read nerve transplantation has been done and the patient's condition is distinctly improved.

[3] Journal of the American Medical Association, Jan. 21, 1905.

The experimental work is being carried out on dogs and has consisted essentially in anastomosing the nerves presiding over one group of muscles with those of another. Thus for example, in several instances the peripheral end of the divided sciatic nerve has been joined to the central end of the divided anterior crural, and the peripheral end of the anterior crural with the central end of the sciatic. In these cases the operation was followed by transitory paralysis, but during the third week the animals began to regain power in the affected limb. At first in their attempt to walk the affected limb was extended with a jerky movement, instead of being flexed as it should, and after three or four attempts at using the affected limb the animals apparently became discouraged and ran around on three legs. About a week later the animals had apparently learned to control the limb, at least when walking, although in attempting to run they again became confused and the limb would be extended, when it should have been flexed. Before two months had elapsed, however, these incoordinate movements had disappeared.

These experiments are cited simply as illustrating the lines along which the experiments are being conducted. Many modifications of this plan will of course have to be worked out in detail before the experiments will be reported in full. As compared with tendon transplantation, the only other surgical procedure which can be considered as an alternative, nerve anastomosis, theoretically at least, is the more rational measure. If one is able to restore function to the paralyzed muscle, the functional results should be better than if an attempt is made to compensate for the loss of function of one group by putting an additional tax upon another.

Applied to the treatment of those palsied conditions with uneven distribution of power, in those muscles, which oppose one another, I cannot but feel that in the transference of a proportion of nerve force, in an amount still to be determined, from one group of muscles to another, from the stronger to the weaker, we have at our disposal a means of control which may be productive of gratifying results.